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Forest Health Protection

Pacific Southwest Region

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To: District Ranger, American River Ranger District, Tahoe National Forest

Subject: Evaluation of Stand Conditions in the Last Chance Sierra Nevada Adaptive Management Project (SNAMP) (FHP Report NE08-02)

At the request of Karen Jones, Silviculturist, American River Ranger District, Tahoe National Forest, Danny Cluck, Forest Health Protection (FHP) Entomologist, and Bill Woodruff, FHP Plant Pathologist, conducted a field evaluation of the Last Chance SNAMP on October 3, 2007. The objective of the visit was to identify any insect and disease issues, evaluate stand conditions, and discuss proposed stand treatments. Recommendations provided in this report will assist with the development of silvicultural prescriptions and other management options for these stands. Karen accompanied us in the field.

Background

The Last Chance SNAMP area is located about 18 miles NE of Foresthill, CA at elevations ranging between 4500 and 6500 feet (centered in the middle of townships T14N, R12E: T14N, R13E; T15N, R12E; and T15N, R13E). Annual precipitation is approximately 65-75" inches. This area is primarily Sierra mixed conifer with ponderosa pine (*Pinus ponderosa*), Jeffrey pine (*Pinus jeffreyi*), white fir (*Abies concolor*), red fir (*Abies magnifica*), sugar pine (*Pinus lambertiana*), incense cedar (*Libocedrus decurrens*), Douglas-fir (*Pseudotsuga menziesii*) and black oak (*Quercus kellogii*) growing in wild stands. Several 20 - 40 year old ponderosa pine plantations are also located within the project area. Land management objectives for this approximately 3200 acre project area are to thin trees to reduce stand density, increase tree health, increase structural and spatial diversity, retain large diameter conifers, reduce surface

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and ladder fuels and shift species composition more towards ponderosa pine. Fuel reductions will be further achieved through mastication and/or prescribed fire.

Observations

Note: Due to the large size of the project area, many project units were not inspected and significant insect and disease issues may exist that were not captured during this brief evaluation.

Evidence of fir engraver beetles (*Scolytus ventralis*), roundheaded fir borers (*Tetropium abietis*) and flatheaded fir borers (*Melanophila drummondi*) was present in older dead white and red fir scattered throughout the observed areas near the upper end of Bear Trap Creek. These trees have likely died over the past 6 years.


Figure 1. Western dwarf mistletoe on ponderosa pine

A large pocket of ponderosa pine growing near Peavine Road is heavily infected with western dwarf mistletoe (*Arceuthobium campylopodum*) with both overstory and understory trees affected (Figure 1).

White fir dwarf mistletoe (*Arceuthobium abietinum f. sp. concoloris*) was observed on white fir causing branch and bole swellings.

Evidence of mountain pine beetle (*Dendroctonus ponderosae*) and western pine beetle (*Dendroctonus brevicomis*) attacks was observed on recently faded ponderosa and sugar pines that were subject to prescribed fire. These trees received high levels of cambium injury to their lower boles as indicated by deeply scorched bark (Figure 2).


Figure 2. Basal fire injury on large sugar and ponderosa pines

Annosus root disease (*Heterobasidion annosum*), although not directly observed, is likely present within many of the stands and negatively affecting the health and vigor of true fir.

Western pine beetle activity in nearby ponderosa pine plantations, that are similar in age and size class to ones found within the project area, has resulted in pockets of tree mortality.

White pine blister rust (*Cronartium ribicola*) was observed on a few sugar pines causing branch flagging (Figure 3).

Branch flagging caused by *Cytospora abietis* was observed on red fir (Figure 3). Although not directly observed due to the height of symptomatic branches, this canker disease is typically associated with red fir dwarf mistletoe infections (*Arceuthobium abietinum f. sp. magnificae*).

Discussion and Recommendations

Current tree mortality attributable to insects and/or pathogens is occurring at a low level within the project area. However, Forest Health Protection aerial surveys have detected elevated mortality levels for all tree species over the past 4 years within and adjacent to treatment units (Figure 4). This mortality is generally occurring in true fir, growing in mixed conifer stands, or in ponderosa pine, growing in plantations, at less than one tree per acre. In 2005, mortality was detected over most of the project area at a level of 1 to 5 trees per acre. Elevated levels of tree mortality in this area, as well as in the rest of the Sierra Nevada range, are strongly associated with periods of below normal precipitation. Successive dry years can exacerbate unhealthy stand conditions; typically resulting in higher levels of bark beetle caused tree mortality. For example, the mortality that was recorded within and adjacent to the project area during the period of 2004 -2007 followed successive dry years from 2001 to 2004 within the Sierra Cascade zone (Zone 3, Palmer Drought Severity Index Data for California). Most of these affected stands were in an overstocked condition.

Figure 3. Branch flagging on sugar pine (left) caused by white pine blister rust and on red fir (middle) caused by cytospora canker.

Most of the Last Chance SNAMP stands are also in an overstocked condition, averaging approximately 465 (range 158 – 524) on the stand density index (SDI); the maximum SDI for managing ponderosa pine density, the desired condition in this area, is approximately 450. This puts many of these stands in a relative density range of over 100 percent (range 35 to 116 percent). This is well above the Regional Forester's recommendation for density management that suggests SDI levels be maintained below 60% of maximum SDI. This high stand density also puts these stands at risk for elevated levels of bark beetle caused mortality during any extended period of below normal precipitation.

This area has become very dense with white fir through past management activities and with the exclusion of fire over the past 100+ years. With such a high percentage of white fir in the area, shade intolerant species such as ponderosa pine as well as many shrub species, tend to decline due to competition for sunlight, water and nutrients. Higher percentages of white fir in mixed conifer stands can also increase susceptibility to defoliation events caused by the Douglas-fir tussock moth (DFTM) (*Orgyia pseudotsugata*). In California, white fir is the preferred host species for the DFTM and outbreaks have tended to occur on ridge tops, upper slopes and generally poorer sites with high percentages of white fir. Past outbreaks where heavy defoliation

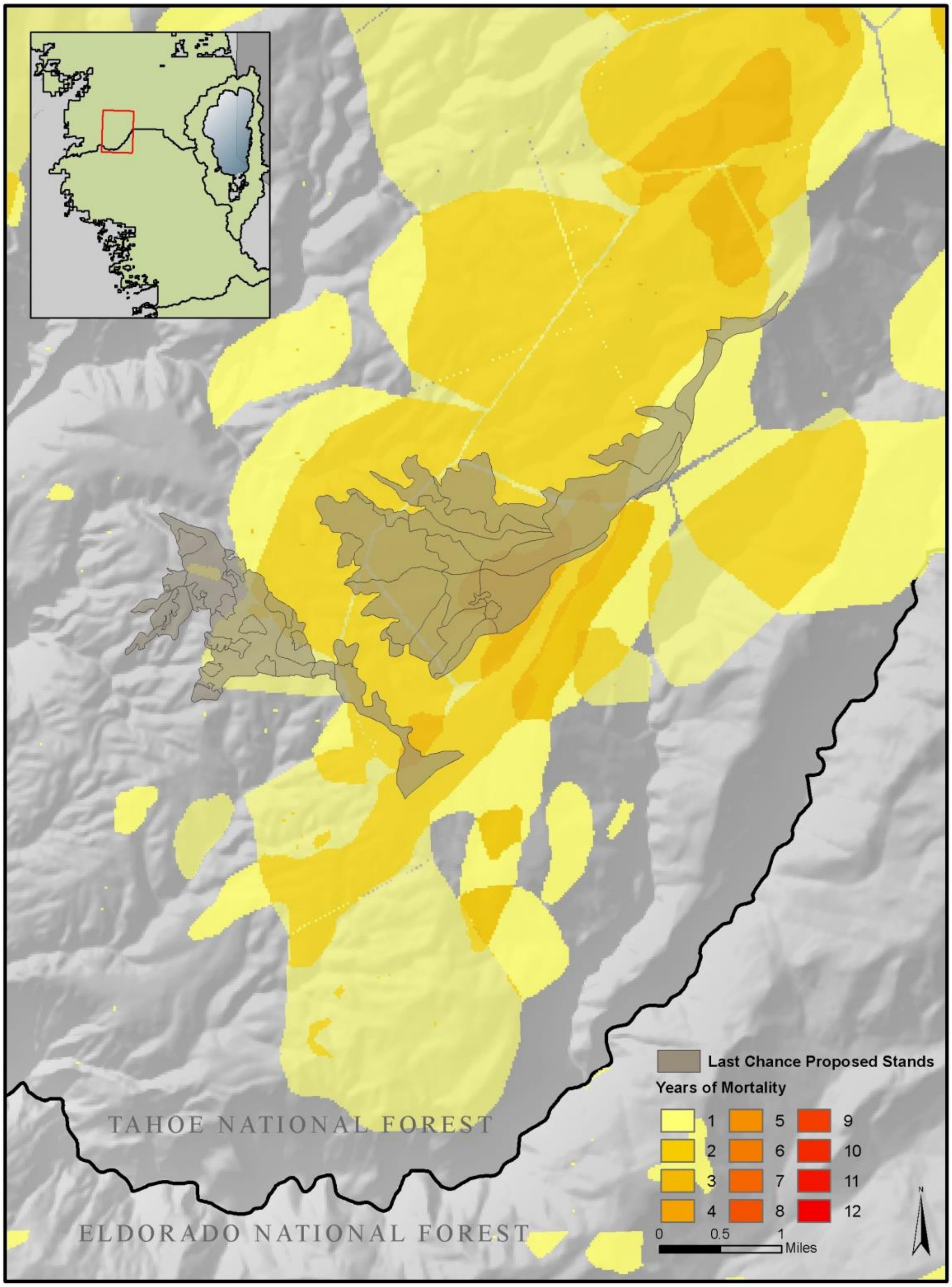

Figure 4. Number of years of mapped mortality between 1996 and 2007 within and adjacent to the Last Chance SNAMP.

has occurred resulted in approximately 20 - 25 % mortality with lower levels of top kill. Management practices that increase stand vigor, increase species diversity and promote even aged stand characteristics for the white fir component will increase resistance to DFTM.

The proposed thinning treatments should reduce the density in most stands to a level that reduces the risk of bark beetle caused mortality. In most cases, thinning to a stand density that is 80% or less of "normal" basal area for the site would effectively reduce tree competition for limited water and nutrients and reduce the susceptibility to future bark beetle related mortality. Thinning to this level would also be consistent with recent direction from the Regional Forester that suggests designing thinnings to "ensure that density does not exceed an upper limit (for example: 90% of normal basal area, or 60% of maximum stand density index)" and to "design thinnings to ensure that this level will not be reached again for at least 20 years after thinning." (Regional Forester letter, "Conifer Forest Density Management for Multiple Objectives", July 14, 2004). However, most areas within the Last Chance SNAMP will require the maintenance of high canopy closure levels for wildlife (a minimum of 40%), resulting in higher stand densities than the recommended upper limit. If canopy cover requirements do not allow for a reduction in stand density that increases the health and vigor of residual trees, the risk for bark beetle caused mortality will remain, especially during prolonged periods of drought. Failure to reduce the risk of bark beetle caused mortality could result in significant mortality, reducing the habitat suitability for some wildlife species and increasing fuel loads.

When planning thinning treatments, it should be recognized that the target stand density is an average to be applied across the landscape and some variability may be desired. Individual high value trees, such as mature pines and black oaks, should benefit by having the stocking around them reduced to lower levels. Areas of pure or nearly pure ponderosa pine would also benefit from lower stocking levels as well as an increase in species diversity. Allowing for denser tree spacing and pockets of higher canopy cover may be desirable around potential wildlife trees, such as fork-topped trees or larger ponderosa pines that have dwarf mistletoe brooms. When implementing thinning projects, retaining more drought tolerant species such as ponderosa pine, Jeffrey pine, sugar pine and incense cedar over true fir will increase species diversity and make the stand more resilient to disturbance agents such as insects, disease, and fire. In addition, when selecting trees for removal, preference should be given to trees heavily infected with dwarf mistletoe, root disease and trees infested with bark beetles. Small group selections should be utilized to remove root disease pockets and clumps of trees with heavy dwarf mistletoe infections. For all thinning operations, it is recommended that a registered borate compound be applied to all freshly cut conifer stumps >14" dbh in order to reduce the chance of new annosus root disease centers being created through harvest activity. However, the treatment of true fir stumps may not be beneficial if stands already have a high level of fir, or S-type, annosus.

Sugar pine should be retained as much as possible during any thinning operation in order to preserve genetic diversity, especially white pine blister rust (*Cronartium ribicola*) resistant individuals. White pine blister rust, a non-native pathogen, has continued to weaken and kill this species over most of its range since its introduction into the Pacific Northwest in 1910. Identification and protection of local rust resistant trees for seed collection, if not already occurring, will aid in the future planting of rust resistant seedlings. Planting selected openings

created through thinning operations with rust resistant stock would help insure this species persists in the area.

The use of prescribed fire as a primary fuels treatment or as a follow up treatment to stand thinning may result in unacceptable levels of tree mortality depending on management objectives. This mortality most often occurs as a direct result of cambium or crown injuries incurred by individual trees during the fire and not from a subsequent build up and spread of bark beetles within the burned stand. Mature ponderosa, Jeffrey and sugar pines are also especially susceptible to mortality during prescribed burns because of the deep duff and litter that accumulates at their base. These duff mounds typically burn at a slow rate, while maintaining lethal temperatures, causing severe cambium injury. If the retention of individual high value black oak and large diameter pine is desired, such as for wildlife habitat, the District should consider raking the duff away from the bases of these trees before burning.

The use of prescribed fire in masticated stands may cause excessive injury to tree boles and root systems resulting in unacceptable levels of tree mortality. These types of injuries and subsequent tree mortality following prescribed fire in previously masticated stands were documented by FHP in the Volcano plantation (see FHP Special Project Report NE-SPR-07-03) on the American River RD. Many trees within this underburn were intensely heated by the combustion of the masticated material that resulted in the killing of the cambium layer. If brush is to be both masticated and burned within the Last Chance SNAMP, it may be necessary to rake some of the chips away from the bases of trees that are to be maintained as residuals or allow enough time between mastication and the underburn to allow the chipped material to decompose enough to alter the flammability and heat intensity.

White fir and red fir occurring in nearly pure stands tend to have very high levels of course woody debris on the forest floor as a result of downed logs from self thinning, the continual shedding of branches and the remaining stems from old stands of brush that have been overtopped and killed by dense fir canopies. These types of stands produce tremendous amounts of heat on the ground surface and often cause severe injuries to the boles and crowns of standing trees. If high post-burn mortality levels in true fir stands, resulting in openings and possibly additional heavy fuel loading, is not an acceptable condition than fuel treatments such as hand or tractor piling of course woody debris should be considered prior to or in place of prescribed fire.

<u>Potential for FHP Funding</u>

Forest Health Protection may be able to assist with funding, including NEPA, for thinning and removing green material from overstocked areas and treating fuels within the Last Chance SNAMP. Thinning projects in this area would meet the minimum requirements for western bark beetle funding and are supported by this evaluation. If you are interested in this competitive funding please contact me for assistance in developing and submitting a proposal.

If you have any questions regarding this report and/or need additional information please contact Danny Cluck at 530-252-6431 or Bill Woodruff at 530-252-6680.

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Insect and Disease Information

Western pine beetle

The western pine beetle, *Dendroctonus brevicomis*, has been intensively studied and has proven to be an important factor in the ecology and management of ponderosa pine throughout the range of this host species (Miller and Keen 1960). This insect breeds in the main bole of living ponderosa pine larger than about 8 inches dbh. Normally it breeds in trees weakened by drought, overstocking, root disease, dwarf mistletoe or fire. Adult beetles emerge and attack trees continuously from spring through fall. Depending on the latitude and elevation, there can be from one to four generations per year.

Evidence of Attack

Initial attacks are made about mid-bole and subsequent attacks fill in above and below. Pitch tubes are formed on the tree trunk around the entry holes. The pitch tubes are red-brown masses of resin and boring dust. Relatively few, widely scattered, white pitch tubes usually indicate that the attacks were not successful and that the tree should survive. Pheromones released during a successful attack attract other western pine beetles. Attacking beetles may spill over into nearby apparently healthy trees and overwhelm them by sheer numbers.

Life Stages and Development

These beetles pass through the egg, larval, pupal and adult stages during a life-cycle that varies in length dependent primarily upon temperature. Adults bore a sinuous gallery pattern in the phloem and the female lays eggs in niches along the sides of the gallery. The larvae are small white grubs that first feed in the phloem and then mine into the middle bark where they complete most of their development. Bluestain fungi, introduced during successful attacks, contribute to the rapid tree mortality associated with bark beetle attacks.

Conditions Affecting Outbreaks

Outbreaks of western pine beetle have been observed, and surveys made, in pine regions of the West since 1899 (Hopkins 1899; cited in Miller and Keen 1960). An insect survey completed in 1917 in northern California indicated that over 25 million board feet of pine timber had been killed by bark beetles. Information from surveys initiated in the 1930s indicates that there were enormous losses attributed to western pine beetle around that time. During the 1930's outbreak, most of the mortality occurred in stands of mature or overmature trees of poor vigor (Miller and Keen 1960). Group kills do not typically continue to increase in size through successive beetle generations as is typical with Jeffrey pine beetle. Rather, observations indicate that emerging beetles tend to leave the group kill area to initiate new attacks elsewhere.

The availability of suitable host material is a key condition influencing western pine beetle outbreaks. In northeastern California, drought stress may be the key condition influencing outbreaks. When healthy trees undergo a sudden and severe moisture stress populations of western pine beetle are likely to increase. Healthy trees ordinarily produce abundant amounts of resin, which pitch out attacking beetles, but when deprived of moisture, stressed trees cannot produce sufficient resin flow to resist attack. Any condition that results in excessive demand for moisture, such as tree crowding, competing vegetation or protracted drought periods; or any condition that reduces that ability of the roots to supply water to the tree, such as mechanical damage, root disease, or soil compaction, can cause moisture stress and increase susceptibility to attack by the western pine beetle. Woodpeckers and predaceous beetles are natural control agents when beetle populations are low.

Mountain pine beetle

The mountain pine beetle, *Dendroctonus ponderosae,* attacks ponderosa, lodgepole, sugar and western white pines larger than about 8 inches dbh. Extensive infestations have occurred in mature lodgepole pine forests. Group killing often occurs in mature forests and young overstocked stands of ponderosa, sugar and western white pines.

Evidence of Attack

The first sign of beetle-caused mortality is generally discolored foliage. The mountain pine beetle begins attacking most pine species on the lower 15 feet of the bole. Examination of infested trees usually reveals the presence of pitch tubes. Pitch tubes on successfully infested trees are pink to dark red masses of resin mixed with boring dust. Creamy, white pitch tubes indicate that the tree was able to "pitch out" the beetle and the attack was not successful. In addition to pitch tubes, successfully infested trees have dry boring dust in the bark crevices and around the base of the tree. Attacking beetles carry the spores of blue-staining fungi which develop and spread throughout the sapwood interrupting the flow of water to the crown. The fungi also reduces the flow of pitch in the tree, thus aiding the beetles in overcoming the tree. The combined action of both beetles and fungi causes the needles to discolor and the tree to die.

Life Stages and Development

The beetle develops through four stages: egg, larva, pupa and adult. The life cycle of the mountain pine beetle varies considerably over its range. One generation per year is typical, with attacks occurring from late June through August. Two generations per year may develop in low elevation sugar pine. Females making their first attacks release aggregating pheromones that attract males and other females until a mass attack overcomes the tree. The adults bore long, vertical, egg galleries and lay eggs in niches along the sides of the gallery. The larvae feed in mines perpendicular to the main gallery and construct small pupal cells at the end of these mines where they pupate and transform into adults.

Conditions Affecting Outbreaks

The food supply regulates populations of the beetle. In lodgepole pine, it appears that the beetles select larger trees with thick phloem, however the relationship between beetle populations and phloem thickness in other hosts has not been established. A copious pitch flow from the pines can prevent successful attack. The number of beetles, the characteristics of the tree, and the weather affect the tree's ability to produce enough resin to resist attack. Other factors affecting the abundance of the mountain pine beetle include nematodes, woodpeckers, and predaceous and parasitic insects. As stand susceptibility to the beetle increases because of age, overstocking, diseases or drought, the effectiveness of natural control decreases and pine mortality increases.

Fir Engraver

The fir engraver attacks red and white fir in California. Fir engraver adults and developing broods kill true firs by mining the cambium, phloem, and outer sapwood of the bole, thereby girdling the tree. Trees greater that 4” in diameter are attacked and often killed in a single season. Many trees, weakened through successive attacks, die slowly over a period of years. Others may survive attack as evidenced by old spike-topped fir and trees with individual branch mortality. Although many other species of bark beetles cannot develop successful broods without killing the tree, the fir engraver beetle is able to attack and establish broods when only a portion of the cambium has been killed.

Evidence of Attack

Fir engravers bore entrance holes along the main stem, usually in areas that are > 4” in diameter. Reddish-brown or white boring dust may be seen along the trunk in bark crevices and in spider webs. Some pitch streamers may be indicative of fir engraver attacks; however, true firs are known to stream pitch for various reasons and there is not clear evidence that pitch streamers indicate subsequent tree mortality or successful attack. Resin canals and pockets in the cortex of the bark are part of the trees defense mechanism. Beetle galleries that contact these structures almost always fail to produce larval galleries as the adults invariably abandon the attack. Pitch tubes, often formed when bark beetles attack pine, are not produced on firs.

Adults excavate horizontal galleries that engrave the sapwood and the larval galleries extend at right angles along the grain. Attacks in the crown may girdle branches resulting in individual branch mortality or "flagging". Numerous attacks over part or the entire bole may kill the upper portion of the crown or the entire tree. A healthy tree can recover if sufficient areas of cambium remain and top-killed trees can produce new leaders. The fir engraver is frequently associated with the roundheaded fir borer and the fir flatheaded borer.

Life Stages and Development

In the summer, adults emerge and attack new host trees. The female enters the tree first followed by the male. Eggs are laid in niches on either side of the gallery. Adult beetles carry the brown staining fungi, *Trichosporium symbioticum,* into the tree that causes a yellowish-brown discoloration around the gallery. The larvae mine straight up and down, perpendicular to the egg gallery. Winter is commonly spent in the larval stage, with pupation occurring in early spring. In most locations, the fir engraver completes its life cycle in 1 year; however at higher elevations 2 years may be required.

Conditions Affecting Outbreaks

Fir engravers bore into any member of the host species on which they land but establish successful galleries only in those that have little or no resistance to attack. Populations of less aggressive species like fir engraver wax and wane in direct relationship to the stresses of their hosts. Drought conditions often result in widespread fir mortality; however, attempting to determine when outbreaks will occur is difficult. Lowered resistance of trees appears to be a contributing factor. Overstocking and the increased presence of fir on sites that were once occupied by pine species may also contribute to higher than normal levels of fir mortality. Several insect predators, parasites and woodpeckers are commonly associated with the fir engraver and may help in control of populations at endemic levels.

Annosus Root Disease

Heterobasidion annosum is a fungus that attacks a wide variety of woody plants. All western conifer species are susceptible. Madrone (*Arbutus menziesii*), and a few brush species (*Arctostaphylos spp.* and *Artemisia tridentata*) are occasional hosts. Other hardwood species are apparently not infected. The disease has been reported on all National Forests in California, with incidence particularly high on true fir in northern California, in the eastside pine type forests, and in southern California recreation areas.

Annosus root disease is one of the most important conifer diseases in Region 5. Current estimates are that the disease infests about 2 million acres of commercial forestland in California, resulting in an annual volume loss of 19 million cubic feet. Other potential impacts of the disease include: increased susceptibility of infected trees to attack by bark beetles, mortality of infected trees presently on the site,

the loss of the site for future production, and depletion of vegetative cover and increased probability of tree failure and hazard in recreation areas.

During periods favorable to the fungus, fruiting bodies (conks) form in decayed stumps, under the bark of dead trees, or under the duff at the root collar. New infection centers are initiated when airborne spores produced by the conks land and grow on freshly cut stump surfaces. Infection in true fir may also occur through fire and mechanical wounds, or occasionally, through roots of stumps in the absence of surface colonization. From the infected stump surface, the fungus grows down into the roots and then spreads via root-to-root contact to adjacent live trees, resulting in the formation of large disease centers. These infection centers may continue to enlarge until they reach barriers, such as openings in the stand or groups of resistant plants. In pines, the fungus grows through root cambial tissue to the root crown where it girdles and kills the tree. In true fir and other non-resinous species, the fungus sometimes kills trees, but more frequently is confined to the heartwood and inner sapwood of the larger roots. It then eventually extends into the heartwood of the lower trunk and causes chronic decay and growth loss.

Heterobasidion annosum in western North America consists of two intersterility groups, or biological species, the 'S' group and the 'P' group. These two biological species of *H. annosum* have major differences in host specificity. All isolates of *H. annosum* from naturally infected ponderosa pine, Jeffrey pine, sugar pine, Coulter pine, incense cedar, western juniper, pinyon, and manzanita have, to date, been of the 'P' group. Isolates from true fir and giant sequoia have been of the "S" group. This host specificity is not apparent in isolates from stumps; with the 'S' group being recovered from both pine and true fir stumps. These data suggest that infection of host trees is specific, but saprophytic colonization of stumps is not. The fungus may survive in infected roots or stumps for many years. Young conifers established near these stumps often die shortly after their roots contact infected roots in the soil.

Dwarf Mistletoe

Dwarf mistletoes (Arceuthobium spp.) are parasitic, flowering plants that can only survive on living conifers in the Pinaceae. They obtain most of their nutrients and all of their water and minerals from their hosts.

Dwarf mistletoes spread by means of seed. In the fall the fruit ripen and fall from the aerial shoots. The seeds are forcibly discharged. The seed is covered with a sticky substance and adheres to whatever it contacts. When a seed lands in a host tree crown, it usually sticks to a needle or twig, where it remains throughout the winter. The following spring the seed germinates and penetrates the twig at the base of the needle. For the next 2-4 years, the parasite grows within the host tissues, developing a root-like system within the inner bark and outer sapwood, and causes the twig or branch to swell. Aerial shoots then develop and bear seed in another 2-4 years.

Dispersal of dwarf mistletoe seeds is limited to the distance the seeds travel after being discharged. From overstory to understory, this is usually 20 to 60 feet, but wind may carry them as far as 100 feet from the source. A rule of thumb is that the seeds can travel a horizontal distance equal to the height of the highest plant in an infected tree. There is some evidence that long distance spread of dwarf mistletoe is occassionaly vectored by birds and animals.

Vertical spread within tree crowns of most dwarf mistletoes is limited to less than one foot per year because of foliage density. Because of the thin crowns of gray pine, however, the vertical rate of spread has been measured as being greater than 2 feet per year. This rate of spread equalled or exceeded the rate of height growth of infected trees.

Dwarf mistletoes are easy to identify because they are generally exposed to view within a tree's crown. Signs of infection include the yellow-green to orange mistletoe plants, basal cups on a branch or stem where the plants were attached and detached plants on the ground beneath an infected tree. Symptoms include spindle-shaped branch swellings, witches' brooms in the lower crown, and bole swellings.

White Pine Blister Rust

White pine blister rust is caused by Cronartium ribicola, a non-native obligate parasite that attacks 5-needled pines and several species of Ribes. The fungus needs the two alternate hosts to survive, spending part of its life on 5-needled pines and the other on Ribes. The disease occurs throughout the range of western white pine and sugar pine to the southern Sierra Nevada, but has not been reported further south. Infection of pines results in cankers on branches and main stems, branch mortality, top kill, and tree mortality.

Spores (aeciospores) produced by the fungus in the spring on tree bole or branch cankers are wind-disseminated to Ribes where they infect the leaves. Spores (urediospores) produced in orange pustules on the underside of the leaves re-infect other Ribes throughout the summer, resulting in an intensification of the rust. A telial spore stage forms on Ribes leaves in the fall. Teliospores germinate in place to produce spores (sporida) which are wind-disseminated to pines and infect current year needles. Following infection, the fungus grows from the needle into the branch and forms a canker. After 2 or 3 years, spores are produced on the cankers and are spread to Ribes to continue the cycle. Although blister rust may spread hundreds of miles from pines to Ribes, its spread from Ribes back to pines is usually limited to a few hundred feet.

Branch cankers continue to enlarge as the fungus invades additional tissues and moves toward the bole. Branch cankers within 24 inches of the bole will eventually form bole cankers. Bole cankers result in girdling and death of the tree above the canker. Cankers with margins more than 24 inches from the main bole are unlikely to reach the bole and only branch flagging will result.